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EFFECTIVE TURBULENCE MODELS IN WIND FARMS (abstract-ID: 152)

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The increase in turbulence intensity in wakes behind wind turbines can imply a significant reduction in fatigue lifetime of wind turbines. In IEC 61400-1:2005 a model is described for effective turbulence in wind farms. This model is based on linear SN-curves and Miner's rule. In this paper this model is evaluated from a probabilistic point of view, including the importance of modelling the SN-curve by linear or bi-linear models. Further, the influence on the fatigue reliability is investigated from modelling the fatigue response by a stochastic part and a deterministic, sinusoidal part with frequency

Behind a wind turbine a wake is formed where the mean wind speed decreases slightly and the turbulence intensity increases significantly. The change is among other things dependent on the distance between the wind turbines. In this paper fatigue reliability of main components in wind turbines in clusters is considered. The increase in turbulence intensity in wakes behind wind turbines can imply a significant reduction in the fatigue lifetime of wind turbine components. In the wind turbine standard IEC 61400-1:2005 is presented a model to determine effective turbulence intensity in wind farms. This model is based on fatigue strengths modelled by linear SN-curves without endurance limit. However, when applying the effective turbulence that assumption shall not be propagated, and thus the load spectra should be derived from the response series by e.g. rainflow counting and the fatigue life should be derived by integrating with the actual SN curve. Possible error/uncertainty introduced by the simple, one-slope power law SN curve is investigated for the different typical details checked for fatigue.

A probabilistic approach is used to evaluate the effective turbulence model. The fatigue reliability of main components in wind turbines in clusters is considered. This includes welded details e.g. in the tower, cast steel details in the nacelle and fibre reinforced details in the blades. The results indicate that it is acceptable to use the effective turbulence model also in cases where a bi-linear SN-curve is used. Further, the paper shows the increase reliability level by using bi-linear SN-curves instead of linear SN-curves.

The influence on the fatigue reliability in wind farms with wakes is also considered in cases where the fatigue load spectrum is modelled not only by a stochastic part related to the ambient turbulence and the eigenfrequencies of the structure, but also additionally a deterministic, sinusoidal part with frequency of revolution of the rotor. This deterministic part is important for many fatigue sensitive details in wind turbine structures. The results show that the effective turbulence model is good and only slightly conservative.